User satisfaction evaluation of an educational distance-learning platform with MUSA methodology

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ABSTRACT

The purpose of this study was to provide an exhaustive analysis of user satisfaction regarding Moodle, an online educational platform, employing an innovative approach through Multicriteria Satisfaction Analysis (MUSA). Contrary to the traditional methods of assessing parameters like Ease of Use and Effectiveness, our study considered unique criteria including Technical Dimension, Possibilities of Teachers/Participants, Pedagogical Dimension, and Automated Functions. The distinctiveness of our approach was amplified by the application of MUSA for criteria weight selection, deviating from the conventional Pairwise Comparison methodology and its reliance on extensive questionnaire administration. Our methodology encompassed the distribution of online questionnaires via Google Forms to a sample of 100 participants from Greece, focusing on the bespoke criteria to derive a holistic perspective of user satisfaction. The MUSA algorithm was instrumental in not only delineating the analytical satisfaction evaluation but also in formulating a structured improvement action plan for the educational platform. A noticeable variance in criteria weight selection was observed when juxtaposing the MUSA algorithm and the traditional Pairwise Comparison methodology, underscoring the precision and reliability of our approach. The findings emanating from the application of MUSA underscore its potential as a pivotal tool in enhancing the quality and user satisfaction of educational platforms. Practical implications of the study are profound for software developers and educational institutions alike. The integration of MUSA into the design and evaluation process of educational software promises a pathway to incessant refinement, aligning with the dynamic needs of educators and learners, thereby elevating the educational experience to unprecedented heights.

Keywords: *Decision-making process, Distance learning educational platforms, MUSA algorithm, Pairwise comparison methodology, User satisfaction evaluation, Weight criteria.*

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Highlights of this paper

- This study presents an innovative assessment of user satisfaction for Moodle, an online educational platform, employing Multicriteria Satisfaction Analysis (MUSA), surpassing traditional evaluation methods.
- The research, involving 100 participants, showcases the efficiency of MUSA in detailing user satisfaction and formulating structured improvement actions, compared to the conventional Pairwise Comparison methodology.
- The findings underscore the significant role of the MUSA algorithm in enhancing the quality and effectiveness of educational platforms through dynamic, data-driven improvements.

1. INTRODUCTION

During the last couple of decades, the notion of customer or user satisfaction has arised as a crucial strategy for the promotion of all kinds of products and services. Companies have strongly correlated the customers' satisfaction to their overall level of success. Moreover, various academic researchers have strongly suggested that customer or user satisfaction is an essential factor for the creation and maintenance of a strategic competitive advantage. In recent years, especially during the COVID-19 era, numerous researchers have emphasized the importance of adapting products or services to meet evolving user needs and preferences. They suggest that such adaptability is a crucial factor for ensuring the long-term success of a product or service (Pan & Ha, 2021; Peñarroya-Farell & Miralles, 2022; Prasetyo et al., 2021). The results obtained by user satisfaction analysis researches could potentially formulate a policy maker context on the basis of satisfaction and motivation of product or service users (Fedushko & Ustyianovych, 2022; Lebrun, Su, & Bouchet, 2021). Moreover, a couple of studies imply that user satisfaction precedes quality (Neto, Reis, Coimbra, Soares, & Calixto, 2022; Rahardja, Hongsuchon, Hariguna, & Ruangkanjanases, 2021) in contradiction with others which suggest the opposite (Noone, Kimes, Mattila, & Wirtz, 2007; Ryu, Han, & Kim, 2008). In the field of user satisfaction, there exist in recent literature multiple definitions and quantification attempts (Kitsios, Kamariotou, Karanikolas, & Grigoroudis, 2021; Koonsanit & Nishiuchi, 2021). A classical definition (Oliver & DeSarbo, 1988) implies that user satisfaction has a direct correlation with the subjective judgement of users via the personal experiences accumulated in educational contexts. Multiple studies have suggested various attributes and dimensions for user/customer satisfaction. User satisfaction means that the user needs are met, service or product features are considered satisfactory and as a result the user experience is overall positive. La and Yi (2015) expressed the various definitions of user satisfaction, which are denoted the subject of interest and the clarification level. The key satisfaction factors include amongst others the service/product performances, the user experiences, user loyalty etc.

Moreover, service quality depends on two main aspects: expected and perceived services. Over the last decade, many studies have revealed the strong connection between service quality and user satisfaction (Balinado et al., 2021; Pakurár, Haddad, Nagy, Popp, & Oláh, 2019). The focus on educational software and the academic sector services evaluation and user satisfaction has been a substantial topic of research during the last decade. For instance, Lupo and Buscarino (2021) developed a measurable methodology using the ServQual Methodology to evaluate user satisfaction with academic e-services, including platforms like Moodle and university websites. They aimed to provide a systematic approach for assessing user satisfaction in these contexts. Similarly, Chen et al. (2020) employed a neural network methodology to evaluate user satisfaction with online education platforms in China, specifically during the COVID-19 pandemic. Their objective was to analyze user satisfaction and gain insights into the effectiveness of these platforms during challenging circumstances.On the other hand Zurita, Baloian, Peñafiel, and Jerez (2019) have use 12 metrics in order to evaluated through a structured questionnaire user satisfaction for an educational mobile application.

Therefore, taking into account the special conditions which arose in various educational systems all around the world because of the pandemic, which include impulsory adoption of distance learning tools and softwares, it is highly important for the academic sector and the software business sector to provide a simple to use and robust tool to measure user satisfaction for educational software and platforms. The objective of this research paper is to explore the application of the MUSA algorithm as a methodology for investigation. The study focuses on a popular e-learning platform, Moodle, which is widely utilized both in Greece and worldwide. The researchers aim to examine the effectiveness and potential of the MUSA algorithm within this specific context.

2. LITERATURE REVIEW

2.1. Educational Evaluation

Over the past few decades, evaluation has emerged as a distinct field of study, drawing from various disciplines. It has become a valuable tool for understanding and implementing policy studies, performance appraisal, engineering design, investment portfolios, and more. While evaluation programs encompass a broad spectrum of definitions and objectives, one commonality is evident: evaluators are dedicated to contributing to social improvement. This objective can only be achieved when evaluation results are effectively communicated to program managers, stakeholders, and other interested parties, thereby informing decision-making and enhancing the program's structure and functionality. The scientific community is actively engaged in this endeavor, recognizing the critical role of evaluation in driving positive change.

One of the fields in which the concept of evaluation applies is in the field of education. Assessment in the classroom requires a lot of time and effort as teachers can spend more than 40% of their time on assessment-related activities. At the same time, however, teachers are neither trained nor have the appropriate knowledge to deal with this difficult task (Stiggins, 1988). Over the last two decades educational research has shown that it is very difficult to apply new assessment methods and especially those aimed at assessment to test learning as a change in student behavior (Black & Wiliam, 2009; Stiggins, 2005).

The main evaluation categories are the following:

Cumulative evaluation: is called when they are made at the end of a process and the conclusion reached is applicable in the near future. Based on these results, one or more decisions can be made based on this crisis. These decisions may relate to the capacity of an individual or a department or organization. Examples of cumulative assessment are the time when the examiner deems a candidate eligible to obtain a driving license, the award of a degree to a student through examinations and a set of tests (examinations, assignments, attendance, etc.) and finally the process in which a candidate is deemed worthy of a higher promotion to a university institution (eg promotion from an assistant professor to an associate professor).

Formative assessment: validated when the appropriateness of the learning outcomes requirements is determined as specified - must be validated by checking them in relation to the benchmarking performance of that particular academic field.

Diagnostic assessment: this is done at an early stage and aims to examine the elements that accompany the "learning" behavior of students

Evaluation practices in classifying students from best to worst constitute a significant domain of research (Duncan & Noonan, 2007; Harlen, 2005; Leighton, Bird, Orsini, & Heyes, 2010; MacMillan & Nash, 2000; McMillan, 2001, 2003; Simon, Roberts, Tierney, & Forgette-Giroux, 2008; Vandeyar & Killen, 2003; Xu & Liu, 2009). Despite the various methods proposed, prevailing evidence indicates their limited efficacy in facilitating student progress, with feedback being notably absent or strictly utilized for research (Aguirre & Speer, 1999; Griffiths, 2006; Remesal, 2006; Sato & Kleinsasser, 2004). Consequently, there's a need to enhance these evaluative practices to be more constructive and beneficial for student development.

In particular, the strong influence of assessment in the teaching process has been documented since the late 1980s-1990s (Black & Wiliam, 1998, 2009; Clarke, 1995; Nunziati, 1990; Stiggins, 1988; Volante & Fazio, 2007). At the same time it was realized at that time that school assessment is a complex process that involves collecting data from students, from school, from teachers' skills and from a variety of other factors. Thus it seems that the teaching process including assessment and learning are intertwined.

Vaden-Goad (2009) explored the distinctions between formative and cumulative evaluation in an experimental study, uncovering a notable increase in information volume and motivation levels when shifting from cumulative to formative assessment. In a separate study by Gotch and French (2011), findings highlighted elementary teachers' proficiency in categorizing assessment types and deciphering student grades, attributing a level of specialization to the educators. However, when it came to employing standardized scores to inform educational decisions, an apparent deficiency in teachers' capability was identified.

Yamtim and Wongwanich (2014) investigated teacher school assessment levels primary education. A study conducted at Wat Phai Rong Wua School involved the participation of nineteen elementary school teachers who completed a classroom assessment questionnaire. Additionally, a focus group discussion was conducted with eight teachers. The results of the study revealed that a majority of the participants demonstrated inadequate assessment knowledge, as indicated by their poor grades. Based on this finding, the researchers proposed a developmental approach to improving primary school classroom assessment literacy that emphasizes collaborative learning and teamwork.

Babaii and Damankesh (2015) examined how high school final exams affect students' utilization of strategic testing and their preparation methods. Their study concluded that such exams lead students to adopt strategies detrimental to their learning, steering them towards a measurement-centric approach instead of focusing on learning enhancement. In the realm of education, assessment serves dual fundamental purposes, as articulated by Stiggins (2005) and Yamtim and Wongwanich (2014). It not only fosters reflection and evolution in teaching and learning practices but also acts as a benchmark for varied stakeholders including families, communities, and school administrations, a role often referred to as the pedagogical function of assessment.

2.2. Case Study Distance Learning Platform - MOODLE

Moodle stands as both an acronym and a verb, each encapsulating its essence. As an acronym, it represents a "Modular Object-Oriented Dynamic Learning Environment", and as a verb, it signifies the act of aimlessly yet creatively wandering (Becerra & Daniela, 2018). Each component of the acronym Moodle unravels a distinct aspect of its functionality. The "Modular" aspect indicates its composition of individual code pieces (modules), each assigned a specific function, such as quizzes or discussion groups, with new modules regularly introduced by the expansive Moodle community. "Object-Oriented" denotes its user-centric design, where the platform's operations are steered by user actions, simplifying the learning curve for its functionalities. Lastly, "Dynamic" underscores its adaptability and continuous updates, enabled by an extensive database that ensures a personalized, dynamic user interface, tailored to individual needs and adjustable by administrators and trainers. As in many computer applications, e-learning applications were developed by more than 60% of developers, without the full guidance of teachers. Most of the time such attempts have failed, since the person directly concerned, in our case the teacher, does not understand or is not facilitated by the application. Here's the difference Moodle is making.

By the term educational content management system we mean the distance learning platform. In order for any platform to work 100%, it needs to be powered by information. This information can be given by the teacher in his lesson, information such as lesson delivery, useful connections inside and outside the network, documents, presentations, programs, competitions, etc., which are stored in his lesson. As a result, he does not have to rewrite them if he is later asked to teach the same subject. With the process of retrieving a lesson from the platform, it can get all this information on one medium and install it later on another Moodle platform. The goal is not to have to spend time for the same purpose again.

The trainees for their part enjoy the services provided by the platform with interest as they are in an environment that alone can not be described as boring.

The main reasons for the prevalence of Moodle are summarized below (Horvat, Dobrota, Krsmanovic, & Cudanov, 2015):

- It has the largest and best organized user base, to provide support to administrators and users.
- It has the largest set of features, so it can support a wide variety of teaching approaches.
- Uses familiar, mature and powerful technologies.
- It is immediately customizable, depending on the needs of the courses and the users.
- It offers an economical solution which in many cases is more flexible than commercial Software Development Models (SDMs).

Moodle is compatible with any web server that can facilitate the Hypertext Preprocessor (PHP) programming language and is equipped with a database. Optimal performance and enhanced support are observed when it is operated on an Apache web server with a My Structured Query Language (MySQL) database, specifications that are accessible with the majority of commercial web hosts, including budget-friendly options. The installation of Moodle encompasses three distinct locations within the web host's infrastructure, as outlined by Ifinedo, Pyke, and Anwar (2018):

1. The application occupies a directory, with many subdirectories for the various modules.
2. According to the system architecture of Moodle, the files uploaded by students and faculty, such as photographs and submitted assignments, are stored in the Moodle data directory.
3. On the other hand, the content generated within Moodle, including websites, quizzes, labs, as well as grades, user information, and user log files, are stored in the Moodle database. This separation allows for efficient management and retrieval of the different types of data within the Moodle learning management system.

Moodle, like most E-Learning/ Learning and Content (EL / LAC) web applications, is developed in the PHP programming language and uses MySql as a database. The operating system can be any, as long as it supports the above functions.

2.3. MUSA Algorithm Applications for User Satisfaction Measurement

The MUSA methodology has been integral in shaping standard evaluation models, primarily for analyzing customer satisfaction, as established by Grigoroudis, Siskos, and Saurais (2000). It evaluates marginal satisfaction functions, aiming for consistency with customer judgments to facilitate the synthesis of individual preferences into an aggregated satisfaction measure. Its applications span sectors including banking, agriculture, transport, and web quality, evidencing its versatility (Grigoroudis et al., 2000).

In a parallel manner, the Utilities Additives Greco, Mousseau & Słowiński (UTAGMS-INT) multi-criteria approach integrates these intricate interrelations as well. MUSA-INT is distinct, featuring a suite of utility functions that epitomize customer contentment, anchored in the potent normal regression approach, an innovation documented by the same authors.

3. METHODOLOGY

3.1. Introduction

For the purposes of the present research a comparison of the weight calculation by MUSA algorithm and Pairwise Comparison Questionnaire was performed. The reason for this comparison is in order to reveal the differences in weight selection (for several criteria) between classical approaches (eg. Pairwise Comparison Questionnaire) and the MUSA algorithm. In this section, the 2 approaches will be described and the results will be compared on the following sections.

3.2. MUSA Algorithm Weight Calculation Methodology

The MUSA method follows the general principles of restrictive qualitative analysis (ordinal regression techniques), using linear programming techniques to solve it (Grigoroudis et al., 2000). The approach discussed includes an additive collective value function, denoted as Y*, and a set of satisfaction functions, denoted as Xi*, which are assessed using the opinions of all respondents. These satisfaction functions represent the evaluation of individual criteria and contribute to the overall assessment of the collective value. The combination of these functions allows for a comprehensive analysis of the data provided by the respondents, enabling a more holistic understanding of the overall satisfaction. The basic equation of linear regression analysis is as follows:

$$Y^*=\sum_{i=1}^{n} b_i X_i^*, \sum_{i=1}^{n} b_i = 1 \qquad (1)$$

In this context, bi represents the assigned weight to the i-th criterion, with functions Y* and Xi* normalized within a range of [0,100]. This normalization ensures that the lowest satisfaction level corresponds to a 0 value, while the highest aligns with a 100 value. Incorporating a dual error variable transforms the qualitative regression analysis of Equation 1 into a new form.

$$\tilde{Y}^* = \sum_{i=1}^{n} b_i X_i^* - \sigma^+ + \sigma^- \qquad (2)$$

n this scenario, $\tilde{Y}^*$ is an estimation of the collective value function Y * and σ + and σ- denoting the overestimation and underestimation errors, respectively. The method aims to minimize the deviation between the value function Y * and the perspectives of respondents Y, integrating a variety of satisfaction points into the unique functions Y * and X_i^*.

Table 1. MUSA methodology variables.

Variable	Description
Y	Y Overall user satisfaction
α	a Number of levels of total satisfaction
y^m	Level y of total satisfaction (i = 1,2, ..., n)
n	Number of Criteria
X_i	User satisfaction for the ith criterion (i = 1,2, ..., n)
α_i	Number of satisfaction levels for the i - th criterion
x_i^k	The k-th level of satisfaction for the i-th criterion (k = 1,
Y^*	Price function of Y
y^{*m}	Value of satisfaction level y^m
X_i^*	Price function of X_i
$x_i^{*}{}^{*}k$	k Value of the $x_i{}^k$ satisfaction level

Souce: Grigoroudis and Siskos (2009).

Table 1 outlines the variables utilized in the MUSA methodology for evaluating user satisfaction. It includes "Y" for overall user satisfaction and "α" to denote the number of total satisfaction levels. Each level of total satisfaction is represented by y^m. The "n" variable indicates the number of criteria considered, while X_i denotes the user's satisfaction for the ith criterion. The α_i variable represents the number of satisfaction levels for each specific criterion,and x_i^k identifies the k-th level of satisfaction for that criterion. The price functions of Y and X_i are expressed as Y^* and X_i^*, respectively. The value of the satisfaction level y^m is represented by y^{*m} and the k value of the x_i^ksatisfaction level is expressed as x_i^* $^*k$. The most important stages of evaluation with the MUSA method are the following (Grigoroudis et al., 2000):

1. Preliminary analysis: At this stage the problem is identified which will be analyzed and will include the detailed evaluation of the objectives of the satisfaction survey and a user behavior analysis and market environment will be performed (Questionnaire and survey).
2. Use of the research questionnaire, the definition of the parameters of the research and its conduct. Specific important characteristics of the research will be identified such as the type of research, the sample, and the process before it is conducted.
3. Analyzes: The information obtained from the sampling will be analyzed and will be quantified by statistical methods and the multi-criteria MUSA method. There will also be a segregation analysis where a separate analysis will be performed for user groups, based on their characteristics.
4. Conclusions and Suggestions: At this stage we have the presentation of the results and the suggestions for specific improvements in the system.

3.3. Pairwise Comparison Questionnaire Methodology

At the first stage of the modeling of the analytical hierarchy, the pairwise comparison of the criteria of the second level of the hierarchy takes place. This comparison concerns the relative importance of the criteria in terms of achieving the final goal of the problem (first level of the hierarchy) which is the selection of the most satisfactory Online education software.

Previous research by Avgerinos and Manikaros (2018) identified criteria for evaluating educational software, including Ease of Use, Efficiency, Effectiveness, and Interactivity/Ease of Memory. However, this study extends and refines these criteria to offer a wider scope of assessment. The updated criteria encompass Technical Dimension, Possibilities for Teachers, Possibilities for Participants, Pedagogical Dimension, and Automated Functions. This enhanced set of criteria is designed to facilitate a more thorough and nuanced evaluation of educational software.

The fisrt step of the methodological procedure is to select the respective weights of each criterion in order to continue through the relevant questionnaires to apply the MUSA model in terms of user satisfaction in relation to each software examined. The weighting of the new criteria uses the pairwise comparison methodology that is widely used in the literature for weight training and requires the use of questionnaires (eg (Bureš, Cabal, Čech, Mls, & Ponce, 2020; Kułakowski, 2020)) The pairwise comparisons of the criteria are made in a table as presented below. In the present study 10 experts completed the pairwise comparison questionnaire as it is illustrated in Table 2 (software engineers, university teachers, phd candidates from Aegean University) and the weighted criteria were calculated on the basis of the results obtained.

In order for the 10 participants to make the comparison between the criteria, the question "How much more important is the criterion, in terms of choosing the most satisfactory educational software, located on the top left of the row compared to the criterion located on the top right?" has to be answered on a quantitative manner. The selection is made on the side where the criterion that prevails over the other is located, ie the criterion which is more important than the other in the selection of the most satisfactory software (the selection of the rating is made according to the Saaty nine-point scale that has wide application in all fields of science, such as in a recent study by Kim, Kim, and Yi (2020). The score obtained by the criterion on the left (for example) side of each row of the table versus the one on the right side of the row in the table above is the inverse of the score of the criterion on the right side of each row against it located on the left side.

Table 2. Pairwise Criteria comparison questionnaire for calculation of criteria weights.

Criterion A	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Criterion B**
Technical dimension	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Teacher opportunities
Technical dimension	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Opportunities for participants
Technical dimension	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pedagogical dimension
Technical dimension	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Automated functions
Teacher opportunities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Opportunities for participants
Teacher opportunities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pedagogical dimension
Teacher opportunities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Automated functions
Opportunities for participants	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pedagogical dimension
Opportunities for participants	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Automated functions
Pedagogical dimension	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Automated functions

The score obtained by the criterion on the left (For example) side of each row of the table versus the one on the right side of the row in the table above is the inverse of the score of the criterion on the right side of each row against it located on the left side.

An example is the following: Suppose a research participant answers that the technical dimension is generally 3 times more important than the capabilities provided by the platform to teachers. Then he has to choose the 3 from the left and the corresponding score that the possibilities of the teachers receive is 1/3.

Table 3. Participant's response snapshot of the comparison of 2 criteria with each other.

Criterion B	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Criterion B**
Teacher dimension	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Teacher opportunities

Table 3 illustrates the participants' responses to a comparison between Criterion B and the Teacher dimension. The data is presented in a matrix format, showing a gradation of responses from 9 to 1 and back to 9 again, reflecting the relative weighting or importance of Criterion B compared to Teacher opportunities. The numbers 9 to 1 indicate stronger weighting to Criterion B, while the numbers 1 to 9 in the second half of the table indicate a shift towards a stronger weighting for Teacher opportunities. This table is typically indicative of a pairwise comparison used in methodologies like the Analytic Hierarchy Process (AHP), to derive ratio scales and preferences. Obviously if the participating answer to some comparison with the unit price essentially finds the two criteria equivalent to each other. According to the answers of each participant, the corresponding weight register is created for each questionnaire. An illustrative example is given.

Table 4. Answers - example of a survey respondent.

Criterion A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Criterion B
Technical dimension	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Teacher opportunities
Technical dimension	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Opportunities for participants
Technical dimension	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pedagogical dimension
Technical dimension	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Automated functions
Teacher opportunities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Opportunities for participants
Teacher opportunities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pedagogical dimension
Teacher opportunities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Automated functions
Opportunities for participants	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Pedagogical dimension
Opportunities for participants	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Automated functions
Pedagogical dimension	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Automated functions

Table 4 illustrates a comparative analysis between two criteria: Technical Dimension and Teacher Opportunities, using a scale from 1 to 9. The scale values represent the relative importance of one criterion over the other, aiding in prioritizing and weighting these aspects during the evaluation process. The table is structured to provide a detailed, side-by-side comparison, facilitating a clearer understanding of the relationship and significance of these two criteria in the context of educational software evaluation. After obtaining the pairwise comparisons of the criteria in a matrix, the next step is to determine the weight of the matrix elements by calculating the priority vector (" principal vector "- eigenvector) as shown in Table 5. To determine the priority vector, the elements of each column are added together. Next, in order to normalize each column and ensure that the sum equals one (1), the elements of the column are divided by the sum of the column. The resulting values are then added up. Finally, the average of the values in each series is calculated. These results represent the weights assigned to the elements of the matrix, which in this case are the evaluation criteria for the software.

Table 5 depicts the pairwise comparison of five criteria: Technical Dimension, Teacher Opportunities, Opportunities for Participants, Pedagogical Dimension, and Automated Functions. Each cell in the table contains a value representing the relative importance of one criterion compared to another, calculated based on a reciprocal scale. A value greater than 1 indicates a preference for the criterion in the row, while a value less than 1 indicates a preference for the criterion in the column. The diagonal, marked with "I 00," represents the equivalence of each criterion with itself, serving as a reference point for evaluating the comparative importance of the other criteria.

Table 5. Example register of criteria for 1 respondent.

Criterion	Technical dimension	Teacher opportunities	Opportunities for participants	Pedagogical dimension	Automated functions
Technical dimension	I 00	600	3.00	0.50	4.00
Teacher opportunities	0.17	1.00	0.17	8.00	0.25
Opportunities for participants	0.33	6.00	1.00	1.00	0.13
Pedagogical dimension	2.00	0.13	1.00	1.00	0.33
Automated functions	0.33	4.00	800	3.00	1.00

3.4. Weight Calculation Results in Accordance to MUSA Algorithm and Pairwise Comparison Methodology

The final results of the weight criteria obtained for the 10 participants according to the Pairwise Comparison Methodology are the following:

Table 6. Criterion weights according to pairwise comparison methodology.

Criterion	Final criterion weight
Technical dimension	31.54%
Teacher opportunities	15.02%
Opportunities for participants	12.18%
Pedagogical dimension	14.75%
Automated functions	26.51%

Table 6 outlines the weights assigned to each criterion following the pairwise comparison methodology. The "Technical Dimension" has been accorded the highest weight at 31.54%, signifying its paramount importance in the evaluation. This is followed by "Automated Functions" at 26.51%, "Teacher Opportunities" at 15.02%, "Pedagogical Dimension" at 14.75%, and "Opportunities for Participants" at 12.18%. These weights reflect the relative significance of each criterion in the overall assessment framework.

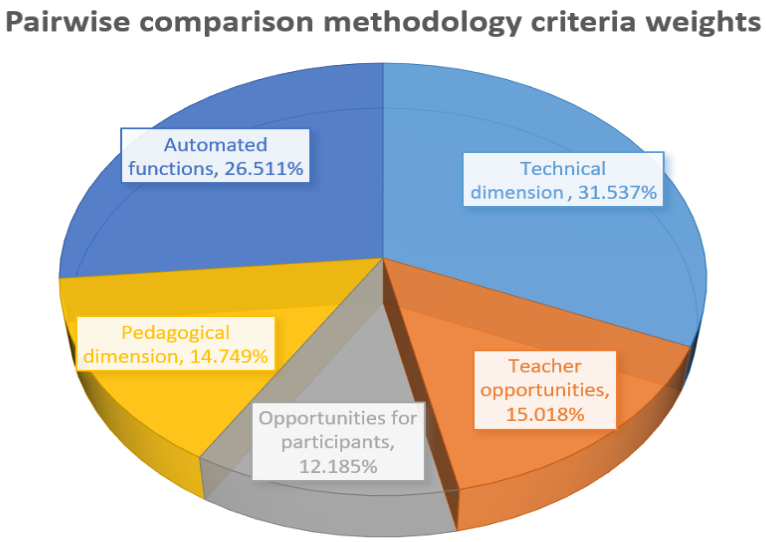

Figure 1. Final criteria weights illustration according to pairwise comparison methodology.

Figure 1 illustrates the final criteria weights as determined by the pairwise comparison methodology. It provides a visual representation, enabling an easy and quick comprehension of the relative importance of each criterion. The lengths of the bars correspond to the percentage weights of the criteria, offering a clear, visual comparison of their respective significance in the evaluation process. The final results of the weight criteria obtained according to the MUSA algorithm (on the basis of the 100 participants) are the following:

Table 7. Final criterion weights according to pairwise comparison methodology and MUSA methodology.

Criterion	Pairwise comparison	MUSA algorithm
Technical dimension	31.54%	22.36%
Teacher opportunities	15.02%	18.19%
Opportunities for participants	12.18%	16.75%
Pedagogical dimension	14.75%	18.52%
Automated functions	26.51%	24.18%

Table 7 compares the final criterion weights as calculated using both the pairwise comparison methodology and the MUSA methodology. Each row represents a different criterion, and the corresponding weights derived from both methodologies are displayed side by side for easy comparison. This layout aids in analyzing and understanding the variations and similarities between the weights assigned by the two distinct evaluation techniques. It is underlined that for the MUSA Algorithm the following assumptions were made:

Near oprimal solutions threshold: 1%.

Global preference threshold: 2 %.

Criteria preference threshold: 2 %.

The corresponding objective value was equal to OV=422.32, the stability index and fitting index was very high (SI=97% and 95.78% correspondingly) and the overall prediction reached 90%.

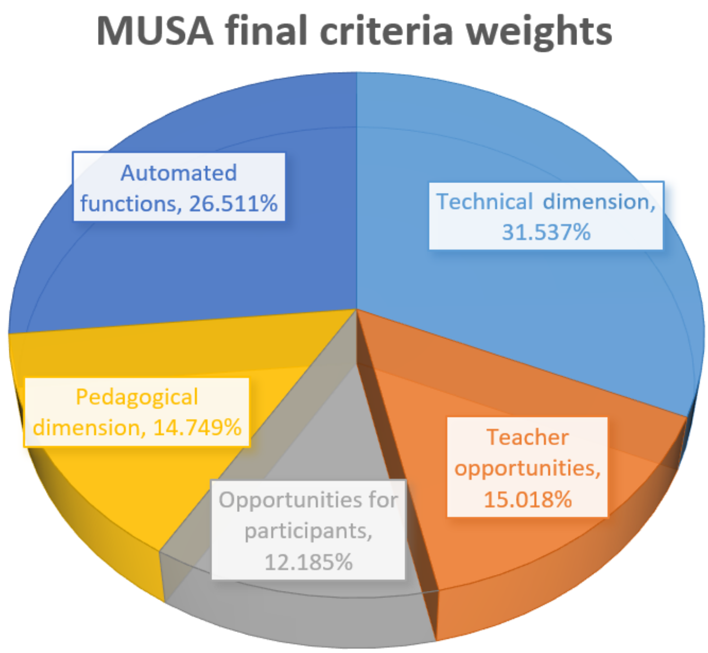

Figure 2. Final criteria weights illustration according to pairwise comparison methodology.

Figure 2 illustrates the distribution of final criteria weights according to the pairwise comparison methodology. In this visual representation, each criterion is depicted as a separate segment, with the size of each segment corresponding to its respective weight. The figure provides a clear and intuitive overview of the relative importance of each criterion, enabling readers to quickly grasp the proportional allocation of weights in the evaluation process. It is obvious that the MUSA algorithm provides slightly differentiated weights in respect to the more classical approach of the Pairwise Comparison methodology. This variance could be explained because the MUSA algorithm calculates the internal criteria weights simultaneously and there is no need of an extra questionnaire. For the rest of the results analysis the MUSA algorithms weights will be used. Nevertheless, it is proven that all methodologies lead to similar criteria weights.

3.5. User Satisfaction Questionnaires – Data Collection

The next step was the distribution of the user satisfaction questionnaires to the survey participants through online Google Forms. The required information was gathered from a specialized Assessment Questionnaire. Thus, each student or teacher interviewed was asked to express his / her judgments and satisfaction, both as a whole and individually in each criterion and individually. A five-point Likert scale was used to compile the questionnaire:

- Totally satisfied.
- Satisfied.
- Somewhat satisfied.
- Not satisfied.
- Absolutely unsatisfied.

For each satisfaction dimension, students surveyed were asked to express their overall satisfaction on the above Likert scale on a scale of 0-4 (not at all satisfied to fully satisfied) and also their satisfaction with the individual criteria used in each dimension. Finally, a couple of demographic questions were included in the first part of the questionnaire. In total 100 participants took place in the present survey (50 teachers of second or third grade education and 50 university students) during 1/11/2021 and 30/11/2021. An anonymity disclosure was included at the first part of the questionnaire along with the brief description of the educational purposes of the present research. Moreover, any participant who changed his/her mind after the completion of the questionnaire and wished his/her answers not to be included in the survey results, was given the option till 15/12/2021 not send an email of exclusion to the research authors.

4. RESULTS

4.1. Descriptive Statistics

In respect to the demographic features of the research sample, 59% of the participants were males and 41% were females. Moreover, 60% of the sample were university or high school students and 40% were high school or university teachers. The overall satisfaction frequencies among the 100 participants for the 5 criteria are presented on the following table.

Table 8. Frequency distribution of satisfaction for the 5 criteria.

Criteria / Grades	0	1	2	3	4
Technical dimension	8.00%	14.00%	23.00%	25.00%	30.00%
Teacher opportunities	12.00%	15.00%	21.00%	28.00%	24.00%
Opportunities for participants	10.00%	18.00%	20.00%	21.00%	31.00%
Pedagogical dimension	17.00%	18.00%	21.00%	25.00%	19.00%
Automated functions	6.00%	11.00%	31.00%	28.00%	24.00%

Table 8 displays the frequency distribution of satisfaction levels for the five criteria, each assessed on a scale of 0 to 4. Each row corresponds to a different criterion – Technical Dimension, Teacher Opportunities, Opportunities for Participants, Pedagogical Dimension, and Automated Functions. The columns present the percentage of respondents who rated their satisfaction at each level for the respective criterion. For example, for the Technical Dimension, 8.00% of respondents rated their satisfaction at level 0, while 30.00% rated it at level 4. This table aids in understanding the distribution of user satisfaction levels across various aspects of the educational platform. The average satisfaction levels for each criterion are shown on the following figure.

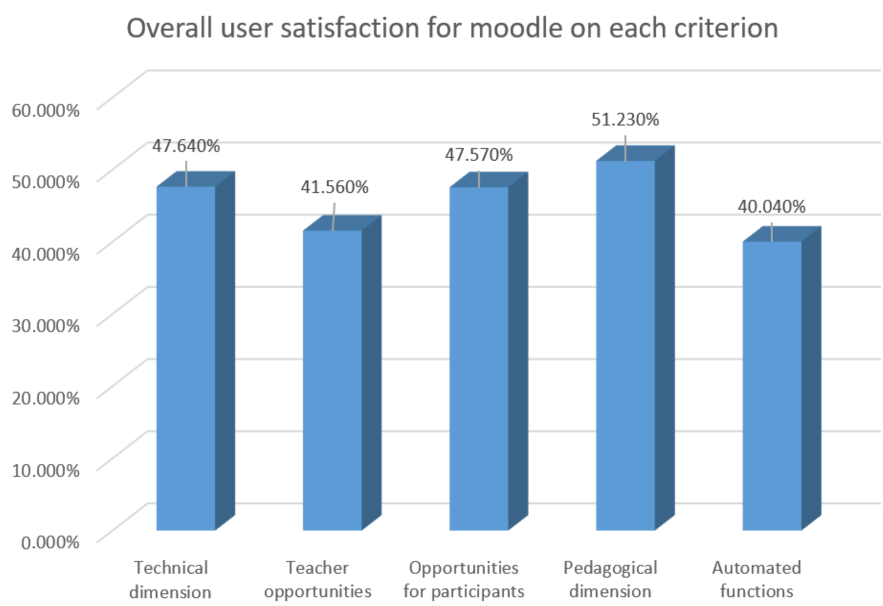

Figure 3. Average satisfaction levels for each criterion.

Figure 3 illustrates the average satisfaction levels for each evaluation criterion. It graphically represents the mean scores, providing a visual insight into how each criterion—such as Technical Dimension, Teacher

Opportunities, Opportunities for Participants, Pedagogical Dimension, and Automated Functions—fares in terms of user satisfaction. The visual representation facilitates an easy comparison and understanding of the areas where the educational platform excels and where improvement is needed, based on user feedback. Each bar's height indicates the average satisfaction score, offering a clear, comparative visualization of user satisfaction across different criteria. And on the basis of the criteria weights calculated on the methodology section, the overall user satisfaction for Moodle is the following.

Figure 4 displays the total satisfaction levels, providing a comprehensive visual representation of user contentment across the board. Each bar in the figure represents the aggregate satisfaction derived from all evaluation criteria, showcasing a holistic view of the users' experience and satisfaction with the educational platform. It offers a clear, at-a-glance insight into the overall performance and acceptance of the platform by the users, allowing stakeholders to quickly gauge the effectiveness and areas for improvement in the user experience. The height of each bar corresponds to the cumulative satisfaction level, facilitating an immediate visual comprehension of the overall user sentiment. The next step of the MUSA algorithm is to provide the demanding percentages for each of the criteria. This is shown on the following graph.

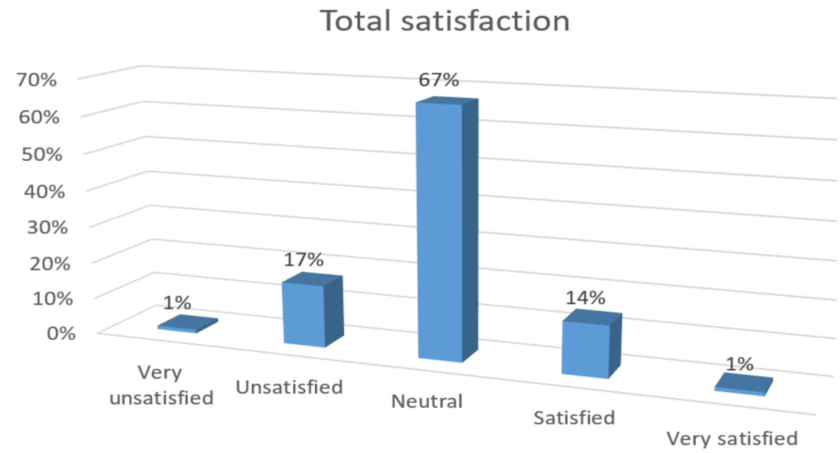

Figure 4. Total Satisfaction levels.

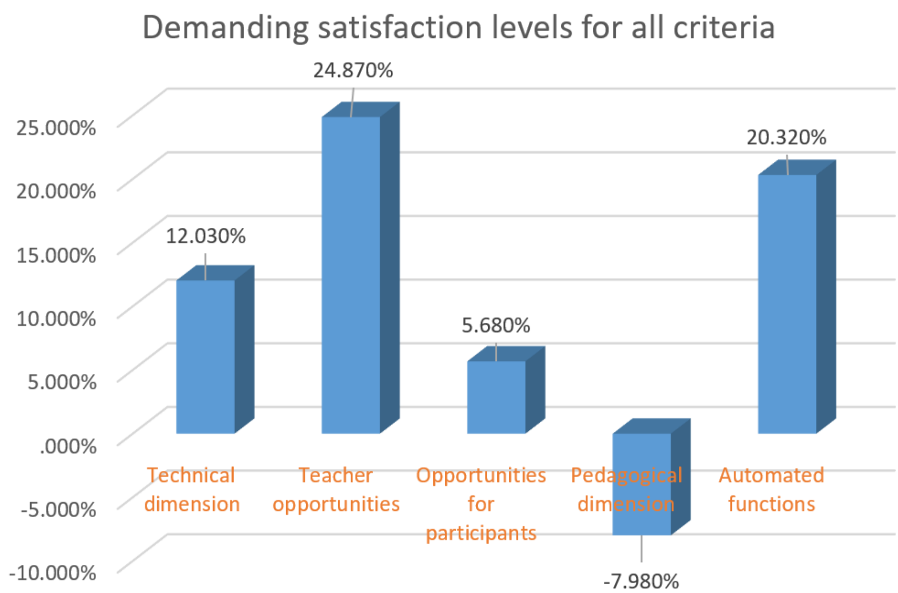

Figure 5. Demanding Satisfaction levels for all criteria.

Figure 5 depicts the varying levels of satisfaction for each MUSA criterion, allowing viewers to quickly assess which criteria are being met effectively and which need improvement. The data visualization may consist of bars, lines, or other graphical elements representing different satisfaction levels, offering a clear, visual representation of performance in each criterion area. This helps in pinpointing specific areas that require attention for enhanced user satisfaction. The action map which is formulated on the basis of the aforementioned results can be shown below.

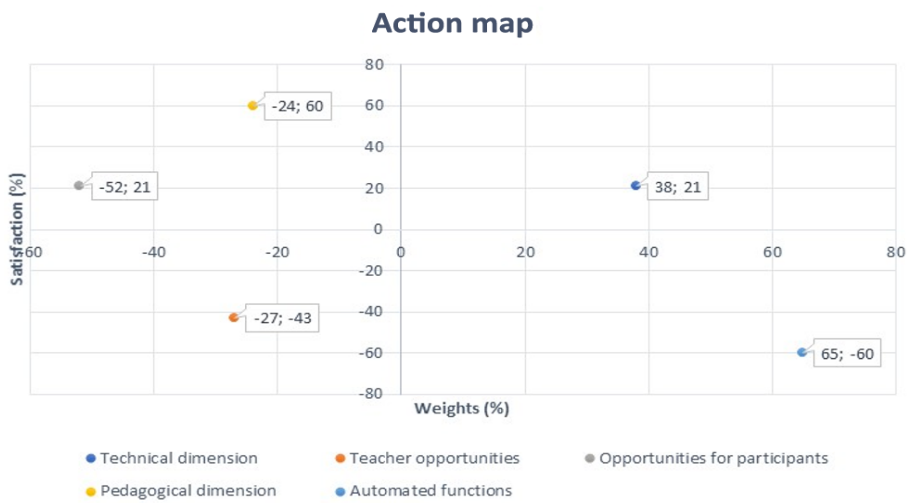

Figure 6. Action map of MUSA algorithm for MOODLE software.

Figure 6 illustrates the action map generated by the MUSA algorithm specifically for evaluating MOODLE software. It provides a visual representation of the various elements and interactions within the software that have been assessed using the MUSA methodology. Each component or action within the MOODLE software is plotted on the map, highlighting areas of strength and those requiring improvement. The visual aid allows educators, developers, and other stakeholders to quickly identify and understand the aspects of MOODLE that are performing well and those that need enhancement to improve user satisfaction and overall efficiency. The action map serves as a practical tool for targeted improvements and informed decision-making in the ongoing development and optimization of the MOODLE software. Figure 6 reveals the overall Action Map according to the MUSA algorithm. It is obvious that the Pedagogical Dimension is the most demanding aspect to be improved (higher demands of satisfaction = 60%). The Automated Functions have the lower demands of improvement (-60%). The improvement map is shown below.

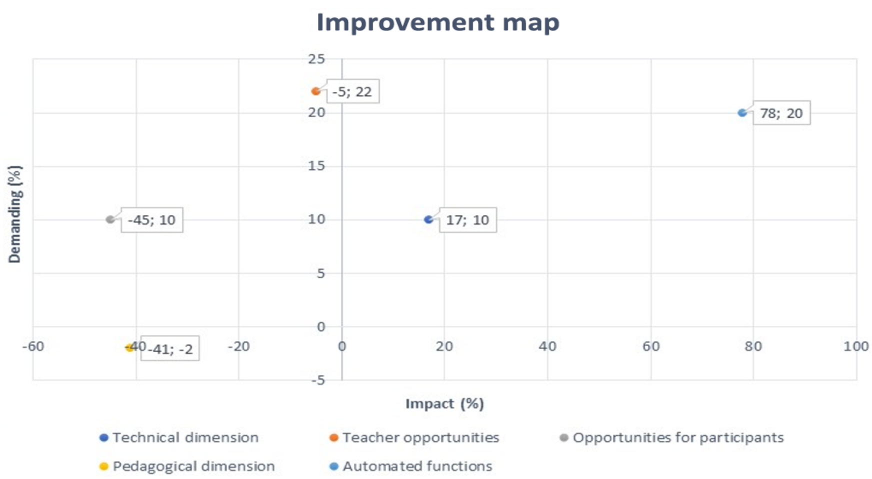

Figure 7. Improvement Map of MUSA algorithm for MOODLE software.

Figure 7 showcases the Improvement Map created using the MUSA algorithm for MOODLE software. This visual tool highlights specific areas within the MOODLE system that require enhancements to increase user satisfaction. By pinpointing these areas, the Improvement Map serves as a strategic guide for developers, administrators, and educators to focus their efforts on making precise adjustments and refinements. It aids in prioritizing the allocation of resources and efforts to areas that will yield the most significant improvements in user experience, functionality, and overall satisfaction with the MOODLE platform. The map is instrumental in facilitating a targeted and efficient approach to the ongoing development and enhancement of the educational software. The highest impact is revealed on the automated functions criterion (78%) which combines also the highest demand of improvement (20%). The second higher demand for improvement is shown at the teacher opprotunities criterion (22%) but the impact percentage is relatively low. The technical dimension has a relatively high impact percentage (17%) and a high demand percentage of improvement (10%). The lowest impact is shown at the Teacher opportunities (-41%) and the participants opportunities (-45%). Nevertheless, the participants opportunities have a high demending ratio of improvement (10%). As a result, the proposed improvement plan for MOODLE platform is the following:

Priority 1. Automated functions. High impact. High demands of improvement.

Priority 2. Technical dimension. High impact. Medium demand of improvement.

Priority 3. Teacher opportunities. Medium impact. High demand of improvement.

Priority 4. Opportunities of participants. Low impact. Medium demand of improvement.

Priority 5. Pedagogigal dimension. Low impact. Low demand of improvement.

5. CONCLUSIONS

The present paper revealed that the MUSA algorithm leads to reliable weights of criteria which are very similar to the weights calculated from other classical methodologies (ie. pairwise comparison methodology). Moreover, it is apparent that the highly succesful and popular educational software MOODLE has various aspects to be improved, according to the improvement map of the MUSA algorithm. The most crucial aspect to be improved is the automated functions (High Impact and high demands of improvement) and the Technical Dimension (High Impact and Medium Demand of Improvement). The technical aspects of any educational platform, as long as the Artificial Intelligence Features, have become lately the most important aspect of any online software or platform, as a result, the present analysis corresponds to the current trend. The MUSA algorithm has demonstrated high reliability in evaluating various software and platforms. Its effectiveness provides a solid foundation for making informed decisions by software companies. The algorithm serves as a valuable tool in assessing the performance and satisfaction of users, offering insights that can guide future actions and improvements in software development and management.

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